





*With the Author's  
Concurrence*

THE

# OXIDE OF NITROGEN

AS AN

ANESTHETIC AGENT.

BY

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IN continuing the study of anesthetics, their special mode of action, the nature of fatal accidents from chloroform, ether, and such like agents of that class, attention has been particularly drawn in the present year to the administration of a comparatively new anesthetic or partially asphyxiating remedy now much used in London—the nitrogen protoxide, or so-called “laughing gas,” which still continues to be exhibited very extensively as a substitute for chloroform.

The very great alleged advantages of this “gas” as an anesthetic have been agitating the profession of late, and very extensive experiments on the lower animals have been instituted to test it.

The author, with a wide experience of chloroform administration, has thought it well to explain, in a few brief observations, how these two agents appear to him to differ; and in this differentiation, what are the physiological advantages, what the good qualities of this “gas,” how it affects the blood, and so on. These remarks profess to be purely clinical rather than speculative or chemical. Added to these purely physiological or clinical suggestions he offers a new theory of the *modus operandi* of the gas as well as some practical remarks on vomiting, so common under chloroform, but absent under this anesthetic.

Having noted with much care, and studied with attention the physiological and one or more commonplace practical results of the nitrogen protoxide administration, these remarks are offered as a sequel to his other papers on anesthetics, as well as to elicit discussion on the general theory of anesthesia so induced.

One of the more obvious phenomena or differences between this gas and chloroform is its influence on the muscles of the entire body, which are not relaxed, but stimulated by the protoxide. Else in many of the more violent surgical operations with this gas on the jaw, where a powerful wedge is placed to keep the jaws asunder, one could not have failed before now to find dislocation of the jaw, if the masseters and other muscles or tissues were relaxed, as they are under ether or chloroform.

A very remarkable "twitching" of the muscles is one of the early diagnostic marks of the patient or subject for surgical operation, being fully under the anesthetic influence of the protoxide. It is entirely different from the struggle under chloroform.

This twitching, according to the views of the author, is caused by dark venous blood irritating the source of muscular power, for all the muscles at one side of the body, in some cases, will be irritated all and severally, and not on the opposite side.

It is not necessary, perhaps, to give any general description of the usual mode of administration of this nitrous oxide gas; suffice it to say, that the procedure is almost identical with the administration of chloroform in hospitals, as familiar to all surgeons. The gas must be pure, and unmixed with air. The patient is found to inhale it quite as readily as chloroform; but the effect to the bystanders is curiously different, nay alarming, when this gas is inhaled. The anesthesia is complete in about sixty seconds.

In place of the calm, gradual sleep under chloroform, the face unaltered, especially in children and women, the same patients, under this gas, are violently agitated, as if in a state of suffocation; the expression of the face is suddenly and entirely altered.

The patients, as a rule, though it is styled "laughing gas," do not laugh, but rather go off into a curiously half epileptic condition, with the invariable twitching or spasm of the muscles, and then total insensibility.

One sees, now and again, very violent apparent distress in some one or two of ten cases under laughing gas, the face of the patient assuming a purple, ghastly, and frightfully death-like aspect; the eyeballs bulging forward from muscular contraction; the expression of the face is like that of a person suffocated. All this is attended with what appears dangerous epileptic, or epileptoid, convulsions, or, possibly, well-marked tetanic spasm or tension. The patient, while under the "gas," to the relatives or friends, and those about

him, wears, it must be confessed, an appearance repulsive in the extreme, as if in the fell grasp of some ghoul, or overwhelming death-struggle! Yet struggle and convulsion will all cease in a moment just as suddenly on admission of atmospheric air. The grasp, as of some monster, on the muscles relaxes; the repulsive appearance of the face, the spasm and tension, the tetanic bending of the body, the convulsions epileptoid or epileptic, the suffocation, the eyes "without speculation," the bulging eyeballs, the ghastly, purple, livid aspect of face, with the other symptoms, all suddenly vanish. The patient, perhaps, smiles, and assures you he has felt nothing at all either of the surgical operation or the struggle. No doubt much of this struggle has been automatic or reflex, but to the friends of the patient it is very horrifying.

In a few instances the violence of the struggle has been so prolonged or great, attended with such marked or startling signs of deadly suffocation, that it was feared at the moment the blood vessels of the brain might give way, especially the arteries, and precaution was taken accordingly.

Yet, still, from the depression of the pulse, so observable under this struggle or full action of the gas, one is inclined to think that there is stagnation in the pulmonary capillaries, and more pressure on the venous system than the arterial. The pulse, as a rule, is suddenly depressed under full action of this gas.

The nitrogen protoxide, when inhaled, as a general rule, is very uniform, and, perhaps, safe in its results; though, by an extended experience, the author has seen exceptions to the general rule of its entire or uniform harmlessness. In one case of a female patient at the Dental Hospital very great alarm was felt by the surgeon for a short time, as, in addition to these signs of struggle, or the asphyxiant stage, the breathing almost at once suddenly stopped, the whole expression of the face became death-like, or fixed as if in marble. Three teeth were extracted passively, or without sign of suffering; the usual bleeding from the gums had stopped. A state like catalepsy came on, but the pulse, which the author carefully marked, continued good all through the period. Vigorous measures to restore breathing were had recourse to, else this patient would probably have died. In a similar case in America the patient never recovered; the cork wedge had got into the pharynx in the struggle!

In another female patient, on the contrary, where, without any anæsthetic or gas, a curious syncope or fainting fit was induced by



fear of the pain of tooth extraction, attended, with utmost exhaustion, at one part of the hospital; the woman was brought, pale and faint, to the operating theatre, where the gas is administered, at another part of the hospital. Few persons would have given such a patient chloroform, if fatal accidents under that agent be due to cardiac syncope. The author watched this patient with painful attention. There was unmistakable syncope present, but the gas, at the first inspiration, restored her to life and spirits. What, then, is the nature of this physiological state, these fears and idiosyncrasy?

It has not yet been proved with sufficient precision what exact amount of carbonic acid gas is given off from the lungs during the four or five minutes such a patient is inhaling the nitrogen protoxide for a surgical operation; or, in other words, how much carbonic acid gas is retained in the blood.

If ordinary asphyxia, with absence of oxygen and accumulation of carbonic acid, be marked, as it is, by stagnation of blood in the pulmonary capillaries, the quantity of blood oxygenized returns to the heart gradually diminishing, its condition becoming more and more venous, till at last the pulmonary circulation ceases or stops—if a warm-blooded mammal can be reduced to a state of hybernation, when the waste of its tissues diminishes so as to require very little carbonic acid gas to be given off—if living animals have been frozen till apparently dead, and brought to life again, this waste of tissues partially suspended, and oxygenation in abeyance, we have in all such cases an analogous state. We know that frogs, caterpillars, snakes, fishes, &c., have been thus frozen till they chinked on glass like bits of ice, and yet were restored to life, so to speak, several days after, on being thawed. This shows, also, that the ordinary process of oxygenation of the blood may be stopped, and yet a low form of life like that under the asphyxia of this “gas” be carried on.

If we now ask what are the advantages of this deadly agent in surgery or medicine, the answer will be in some form as this. The chief advantages of the nitrogen protoxide over chloroform or ether, as far as they have yet appeared, are—(1st), the quickness of action of the gas; (2nd), the slight after effects; but specially, and above all (3rd), the absence of vomiting, which latter, under chloroform (especially when carelessly administered), is sometimes—for instance in ovariectomy or hernia, or eye operations—most troublesome, if not the immediate cause of death!



The author has observed one case, however, out of half a dozen already reported, where vomiting or violent retching occurred under the "gas"—that of a delicate female for a tooth extraction; but, as a general or practical rule now observed in some 800 cases, vomiting is absent. This arises from the gas not irritating the pharynx, œsophagus, and laryngeal nerves.

Then as to the quickness of action of the protoxide. It must in contrast be said the balloons—so useless: *omne ignotum pro magnifico*, as Mr. Simon says of cholera theories: the complex valves, &c., give a glamour of fear and terror to ehloroform that it does not deserve, all which prevents country surgeons from giving it a fair trial. Fear invites all evils. "*Quæ metuunt fingunt*," says Lavater. It is only wise or fair to place in contrast with this the alarming appearance of the patient, and the excessively cumbrous gasometers, tubes, valves, &c., which it is necessary, especially in private practice, to carry about with the surgeon in cases where a few drops of plain ehloroform would, in all probability, if skilfully administered, act quite as well.

A very large fixed gasometer, capable of containing 106 gallons of the nitrogen-protoxide, has been recently, however, placed in the operating theatre of the London Dental Hospital; and even portable small gasometers for single cases, not unlike the ordinary "Hutchinson's Spirometer," have been manufactured for private practice!

How does this gas differ from ehloroform?

The appearance of the patient under chloroform nareosis; the healthy appearance of the scarlet blood of such ehloroform patient in the arterial jet at surgical operations, and such like phenomena in experiments with ehloroform on the lower animals; the comparative manageableness or slowness of the operation of ehloroform contrasted with the general effect so rapid and alarming of the protoxide; the quickness of action, the dark venous character of the arterial blood, the livid, cold, death-like appearance of the surface of the skin under this gas, &c., all tend to show how differently these two agents influence the system.

We have here under this gas rather a modified form of asphyxia, with its insensibility to pain, yet freedom from danger! Probably because the process of asphyxia or hybernation, so to term it, may be stopped at once by permitting air into the lungs in case of danger, and then all anxiety ceases.

Bichât demonstrated, even in his day, that such a form of

hybernation or sleep, with insensibility or modified asphyxia, could be imitated in animals, and was tolerated in cold-blooded animals, especially with cold surface, by passing, as an experiment, the venous blood of such animals into its adjacent artery, or by freezing animals, so common in Spallanzani's experiments.

The nitrous or protoxide "gas" has been administered for a few small surgical cases, such as excision of condylomata, opening of abscesses, amputation of toes, where it is now beginning to be admitted that chloroform has proved more dangerous than in large capital operations. In these special surgical instances one would say—the gas has at once alarmed but satisfied the operating surgeon.

It has helped to magnify the evils of chloroform—rather chloroform in inexperienced hands. The advantages and disadvantages are about equally balanced; but as a physiological study, the gas is very full of interest.

The essential *modus operandi* or action, according to the author, is to afford a passive stimulus to the larger bronchial tubes, while the lower hybernating process of respiration goes on in the pulmonary capillaries. This dark blood, circulating in the systemic arteries, producing this curiously leaden death-like appearance of the patient, and anesthesia.

It is possible the venous condition produced by the gas might hereafter be available in blood-poison cases, snake bites, and such like, where it is advisable to alter the crasis of the blood suddenly; or, in the treatment of aneurism, to favour coagulation in the sac. It might help the degeneration of some malignant tumours into fat; but its use in general surgery must be very limited, on account of its cumbrousness.

Facts such as the following show further the *modus operandi* of the gas:—Several patients have had administered to them the same eight gallons of the protoxide repeated over and over again, three, four, or more times, the same gas inhaled, exhaled, and then inhaled again. Still the gas has not lost any of its sensible properties of rendering the patient insensible. This tends to indicate that this gas is not absorbed or decomposed by the blood in the lung or pulmonary capillaries, but affords a kind of artificial stimulus to the organs of respiration, while a low form of life, as in hybernating animals, is carried on in the capillaries, or air cells.

The author is inclined to believe that this is rather the *modus operandi* than that usually believed—viz., that the gas saturates

the blood, and is given again off unchanged; and for this reason, that any given quantity of seven or eight gallons of the gas has not had time enough thus to mix with the blood, nor are there any traces of the effect of the gas on the blood. As in similar administration of chloroform, vapour or ether, and notably of carbonic oxide, all which act on the blood corpuscles, carbonic oxide breaking up the corpuscles entirely, and ether or chloroform, though not acting so powerfully, being still perceptible in the blood, and easily re-distilled from the blood where thus administered—phenomena all absent as regards this nitrous oxide gas.

The quickness of recovery from the state of asphyxia under the gas, the rapidity with which arterial blood again diffuses itself over the face and neck of the patient, is very wonderful. The arterialization of the blood, on admission of air, is instantaneous. The mode of life of hybernating animals, or of the *fetus in utero*, or in cyanosis, where the two sides of the heart communicate, will afford at least some loose analogous instances of this condition of life carried on with dark blood in the arteries. In the asphyxia under this gas, when air is permitted to the patient, the recovery is as if a spring were relaxed, the red blood rushing at once through the vessels.

Respiration, it need hardly be said, is a function, in a physiological point of view, of a double nature, related on one side to the brain and spinal chord, to which it owes the mechanical action of the lungs, intercostal muscles, diaphragm, &c.; and on the other side to the heart, which is the medium of transit of the blood to be arterialized or oxygenized; and so we have two forms of death in accidents from anesthetics.

In fact, the relation existing between brain and lungs in birds, mammiferous reptiles, fishes, &c., is reciprocal, showing, too, how little we can judge of such accidents in them and the human subject.

Finally, as to the practical value of the protoxide!

As to the absence of vomiting, so desirable, as once believed in eye operations, especially in cataract cases, it is now found in practice that a slight amount of vomiting does not do as much harm, as theoretically supposed, in eye cases. Nor is vomiting very frequent under chloroform, where the surgeon or administrator is familiar with certain methods of preventing vomiting, which arises from irritation of the pharynx, and is probably not "cerebral." In eye operations under the protoxide there is

rather dangerous bulging forward of the eye, caused by the twitching of the muscles of the eyeball. This alone may always render the protoxide of questionable desirableness or superiority as an anesthetic in eye operations. The eye is also found to roll and bulge in a curiously unsteady manner under operation, so that although there be no vomiting there is reason to fear there would be much risk to the vitreous humour or iris in cataract cases, from the protoxide and from this irregular action of the muscles. Nor is the ether spray at all advisable as a local anesthetic in freezing the fluids of the eye. The ether spray, in fact, is entirely without value in tooth-drawing, or eye operations, or large amputations; so that the practical surgeon in all the London hospitals at present is driven back to the adoption of plain chloroform, as at once the simplest anesthetic, and the one best understood by students, nurses, and patients. The ether spray congelation, in fact, is generally discarded in dentistry and eye operations.

The nitrogen protoxide has already been used in London this year in nearly a thousand tooth-drawing operations, where it has given much satisfaction by this quickness of its action, and this entire relief from pain and safety, though condemned at first, in favour of the "spray."

The author of the present communication has no doubt whatever that the relief from pain and general satisfaction would be quite as great if chloroform had taken the place of the nitrogen protoxide in these cases, and if in place of many and abounding popular prejudices against chloroform, which are encouraged too much in our popular literature to favour voltaic narcotism, or methylene or patent "mixtures," the same study and interest could be secured in dental hospitals for chloroform or ether as for this "gas," we should have less reason to be dissatisfied with the older anesthetics, and have less fatal accidents from anesthetics in general.

These chloroform accidents, the author still believes, as first stated *in extenso*, in the "Transactions of the British Association," are due in a large measure to idiosyncrasy or sudden fear on the part of the patient, rather than prolonged exhaustion or narcosis under the chloroform.

These chloroform accidents are sudden, as if from spasm of the glottis and pulmonary apparatus, rather than deep coma or cardiac syncope.

Nearly all the death accidents (now numbering about 300) from chloroform have been in strong, sensitive individuals, during or



before very trivial operations, from fear of coming pain, showing how unwise it is to exaggerate this fear of chloroform in favour of a gas with so few advantages.

The practical medical man, in a word, may have, in tedious long operations like ovariectomy, or in tediously long midwifery cases, when patients struggle almost as if under this "gas," being often livid, comatose, or stertorous (very probably from absence of air), he may have a condition of asphyxia running parallel with the condition of anesthesia, but not identical, but still no danger so long as the respiratory muscles are acting with vigour under the chloroform.

The more immediate cause of danger, as supposed by Dr. Brown-Séquard, being a spasm or reflex irritation sent suddenly in some patients with such idiosyncrasy from the lung to the heart, or, possibly, from the glottis and laryngeal nerves. Perhaps old Melancthon was not so wrong after all: "*Mæstitia cor quasi percussum tremit et languescit*, fear strikes the heart, makes it tremble, and the black blood under the ribs on the left side makes these convulsions so fatal."

The inhalation of the nitrous gas is not attended with any appreciable change of pulse at the wrist till the patient shall have been fully under it; then it becomes suddenly weak, as the dark blood pervades, probably, the heart tissues; whilst, on the contrary, under chloroform, the pulse rises and becomes larger as the anesthesia progresses. This large pulse, as Dr. Brown-Séquard suggested to the author, is not a stimulant, but rather a paralytic action of the coats of the artery. Nor does the pulse sink in ovariectomy, as theoretically supposed, by a synthesis of disease from experiments on animals with voltaic narcotism, or chloromethyl in laboratories; the pulse rises in ovariectomy under chloroform.

The advocates of the coagulation of the blood from escape of ammonia or voltaic narcotism profess themselves no experience of chloroform or nitrous oxide in actual practice; hence many errors.

The author, in conclusion, is of opinion, that it is indeed rather as a physiological study as to experience of such agents in the human subject that the adoption of this anesthetic at present is so worthy of the attention of the profession.

The surgical experiments have been witnessed in London with great and increasing interest; and if we could but ascertain with exactitude, independently of the chemical theory of the synthesis

of disease or diffusion of gases, what exact amount of carbonic acid gas is given off during the period of the asphyxia stage under the protoxide, or what precise quantity of carbonic acid, in other words, is retained in the blood, we might then be in a position to explain the *modus operandi* of the new gas in a more satisfactory manner.

As a physiological study, these experiments in London lend no little corroborative proof to the views already published by the author—namely, that in surgical practice, whatever *a priori* reasoning may say to the contrary, the surgeon, in the use of chloroform or such anesthetics, may have aggravated stertor, and a condition almost like coma, in the patient on the operating table; but it is not so dangerous as sudden spasm!

If the cardiac syncope theory, in fine, were true, no one would be justified in administering chloroform at all.

The nitrogen protoxide too, though condemned hastily, has now been given in America, France, and England, in some thirty thousand cases. It indicates that experiments in animals with the "gas" are only "part of the truth," when brought to bear on the idiosyncrasies or fears of hospital patients. In a word, the condition of the system under this "gas" explains much that was wanting as to whether asphyxia is so dangerous as the advocates of complex inhalers, to prevent cardiac exhaustion from more than three per cent. of vapour, had imagined. Chloroform, as once said of antimony by the good old fathers of the profession, "is like Scanderberg's sword, strong or weak—a poison or a great benefit, as it is used"—a worthy medicine, if applied simply. While this "gas," from which already two deaths come to us from America, with its alleged advantages, does not seem entirely as great as other revolutions, political or journalistic, of the year last passed, and only an indifferent substitute for the old fashioned—chloroform.

A wide and interesting diversity of opinion exists amongst the ablest physiologists, indeed, as to whether the condition under this gas is one of simple asphyxia, or a form of anesthesia, with "deficient oxidation." Dr. Mareet, Dr. Burdon Saunderson, and others, hold our view. Mr. Coleman, and other practical surgeons, like my friend Sir W. Fergusson, still fear the prolonged asphyxia from the gas in long surgical operations; but everything in its future history must depend on whether this is the exact condition, or a modified asphyxia, as I am inclined to think.





